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Buddy taping versus splint immobilization for paediatric finger fractures: a randomized controlled trial

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Abstract

The purpose of this single-centre randomized controlled trial was to assess the non-inferiority of buddy taping versus splint immobilization of extra-articular paediatric finger fractures. Secondary fracture displacement was the primary outcome; patient comfort, cost and range of finger motion were secondary outcomes. Ninety-nine children were randomly assigned to taping or splinting. Sixty-nine fractures were undisplaced; 31 were displaced and required reduction before taping or splinting. Secondary displacement occurred in one patient in the taping and three in the splinting group. The risk difference was below the predefined non-inferiority level of 5%. All secondary displacements occurred in the 31 displaced fractures after reduction and were in little fingers. Patient comfort was significantly higher and cost lower in the taping group. We conclude from this study the non-inferiority of buddy taping versus splint immobilization of extra-articular paediatric finger fractures in general. We advise treatment may need to be individualized for patients with displaced fractures because we cannot make any absolute conclusions for these fractures.

Level of evidence: I

Keywords

Randomized controlled trial, child, fracture, finger, phalanx, treatment

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Introduction

Treatment of most extra-articular paediatric finger fractures with immobilization in a forearm cast yields a high success rate with few secondary displacements and good outcomes. However, immobilization in a forearm cast for 3 to 4 weeks is cumbersome and restricts a child's activities considerably. Furthermore, application of a cast involves adaptation of the splint to a child's hand and cost for material. Therefore, the question arises whether simple interdigital buddy taping without a further splint is sufficient to treat these common fractures successfully.

Buddy taping for the treatment of finger fractures as an adjunct to protective splinting has been recommended in several studies (Figl et al., 2011; Fok et al., 2013; Franz et al., 2012, 2013; Park et al., 2016; Pezzei et al., 1993; Rajesh et al., 2007). The combination of some of these splints with buddy taping allows early mobilization, and it has been demonstrated that this functional treatment prevents stiffening and therefore achieves free mobility and bony healing at the same time. However, splinting limits patients' activities. This restriction has encouraged athletes, particularly in volleyball and basketball, to simply tape many of their finger injuries and return to sports immediately. It is very likely that they have treated not only sprains but also stable fractures by buddy splinting (Aitken and Court-Brown, 2008; Briner and Kacmar, 1997; Chen and Kalainov, 2017; Gaston and Chadderdon, 2012; Shaftel and Capo, 2014).

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Although buddy taping has been used since the seventies, it is only recently that buddy taping without supplementary splinting was introduced as a recognized treatment modality for fractures in the medical literature. Only a few studies, none of them prospective, have been published on the subject (Figl et al., 2011; Franz et al., 2012, 2013; Loosli and Garrick, 1987; Park et al., 2016; Pezzei et al., 1993; Vadstrup et al., 2014). In 2009, buddy taping was recommended as a standard treatment for undisplaced, closed fractures of the proximal phalanx in the American Society for Surgery of the Hand Manual of Hand Surgery (Baltera et al., 2010). In standard textbooks, the indication has been extended in recent years to treat most undisplaced, stable fractures of all phalanges of the index to little finger with buddy taping (Day, 2016). Specific recommendations for children and adolescents were given by Nellans and Chung, who recommended buddy taping as an effective treatment for length-stable fractures with minimal displacement (Nellans and Chung, 2013).

These recommendations and the lack of prospective studies encouraged us to apply taping without splinting in a well supervised preliminary series of children with undisplaced, length-stable finger fractures. The good results with these patients motivated us to extend the indications to include oblique fractures and fractures needing reduction.

The aim of this randomized controlled trial (RCT) was to compare the outcome of paediatric finger fractures treated with interdigital buddy tape (taping) with forearm-based hand splint immobilization (splinting) in a prospective, randomized non-inferiority trial. Secondary displacement was the primary outcome parameter; patient comfort, analgesia intake and total range of active motion (TRAM) were secondary outcome parameters.

Methods

Study design

This study was designed as a single-centre, non-inferiority randomized controlled trial with two arms comparing two non-operative treatment options and follow-up examinations at 3 days, 3 weeks and 6 months. The study was approved by the local ethics committee. Data was recorded in an electronic case report form according to Good Clinical Practice guidelines.

Patients

All children age 4 to 16 years who presented with extra-articular finger fractures at the interdisciplinary accident and emergency unit at our children's hospital between October 2011 and March 2016 were asked to participate. Undisplaced fractures and fractures needing reduction were included. Exclusion criteria were open fractures, multiple fractures on one hand, phalangeal neck fractures, presentation later than 5 days after the injury and insufficient command of the German language. Phalangeal neck fractures were excluded because the collateral ligaments attach to the phalangeal neck and therefore to the small fracture fragment. Taping allows movement in the interphalangeal joints and we were therefore concerned that this movement, that transmits forces to the phalangeal neck, would predispose to secondary displacement and pain. All parents and children older than 10 years who were included gave their informed consent prior to randomization and participation.

According to the protocol, the taping had to be discontinued or supplemented with splinting in cases of a secondary displacement, skin problems, or upon patient's or parent's wishes, particularly in the presence of pain.

Interventions

Initial assessment at the interdisciplinary paediatric accident and emergency unit consisted of clinical examinations and posteroanterior and lateral X-rays. Reduction under nitrous oxide, sometimes supplemented with local analgesia, was performed by emergency physicians for fingers with a rotational deformity, an angulation greater than 10° in the radioulnar plane or an angulation greater than 25° in the dorso–palmar plane. Immobilizations were performed by physicians and specialized nurses according to randomization and parental counselling. Displaced fractures after reduction, oblique and spiral fractures, as well as fractures with multiple fragments, were considered unstable, whereas all other fractures were considered stable (Figure 1). Both stable and unstable fractures were treated identically. All patients of both groups were followed by surgeons at the hand surgery outpatient clinic.

Taping. Treatment included buddy taping of the injured finger to its neighbouring uninjured finger: the index finger to the middle finger, the little finger to the ring finger and the middle and ring fingers together. A standard tape (Strappal®, BSN medical Ltd, Willerby, East Yorkshire, UK) was used with an interdigital padding to prevent skin maceration (Leukotape® foam, BSN medical Ltd, Willerby, East Yorkshire, UK) (Figure 2). The interdigital padding restricted flexion at the interphalangeal joints and thereby contributed to the stability. No further immobilization was applied.

Figure 1. Example of a Salter Harris II fracture of the proximal phalanx of the little finger with successful closed reduction and taping only: posteroanterior and lateral X-rays at initial presentation and after 21 days.

Figure 2. Application of interdigital padding and taping.

Parents and patients were instructed in changing the tape and given a roll of tape to change when desired, for instance after swimming or washing at home.

Splinting. A forearm-based palmar hand splint was applied in an intrinsic plus position, enclosing all fingers without the thumb. A cotton forearm stocking, interdigital cotton padding and a knitted fibreglass substrate impregnated with a polyurethane resin (Scotchcast®, 3M, Ruschlikon, Switzerland) were used (Figure 3).

All patients and parents were followed at the paediatric hand surgery outpatients' clinic with standardized examinations, X-rays and

Figure 3. Application of a forearm-based palmar hand splint.

questionnaires at days 5 and 21. Unprotected mobilization was encouraged in both groups after the day 21 visit with voluntary interdigital taping for sports and other activities as desired. Further clinical visits were made 6 and 24 weeks after injury. No formal rehabilitation was prescribed.

Outcome measures

The primary outcome measure in this study was secondary fracture displacement during the course of immobilization after initial treatment. The displacement was measured on posteroanterior and lateral X-rays at initial presentation, during reduction, at day 5 and at day 21.

The secondary outcome measures were patient comfort, cost, TRAM and time to take to complete the initial treatment. Parents were asked about the duration of analgesia intake of their children in days. Patient comfort as perceived by parents was measured on a visual analogue scale from zero (not disturbing at all) to ten (very disturbing).

The TRAM of the metacarpophalangeal, proximal interphalangeal and distal interphalangeal joints of the injured and the identical healthy finger of the other hand were measured at 6 weeks and 6 months follow-up. Time taken for splint or tape application was measured at the time of initial treatment.

Sample size

For the a priori sample size calculations, we assumed that a risk difference of up to 5% in secondary displacement rate was clinically irrelevant. Given this criterion and assuming the risk difference of taping to be –10%, we can establish non-inferiority with a power of 90% with 50 patients in each group.

Randomization

Patients were allocated to groups in a 1:1 ratio. A computer-generated random list was made and sealed in envelopes. Oral information and consent were collected from all children and parents.

Written information and consent were then collected from parents and children above the age of 10 years. Patients then drew an envelope to be assigned to a group. Physicians, parents and patients were not blinded, but the data analyst remained blinded to the treatment groups while doing the analyses.

Statistical analysis

Continuous data are displayed as means and 95% confidence levels (95% CI). Categorical data are shown in tables. Differences between groups were analysed using a two-sample *t*-test for continuous and a Fisher exact test or Chi-square test for categorical data. The number of secondary displacements within 5 days of treatment was analysed with Newcombe's method 10 (Newcombe, 1998) as the primary outcome parameter. We used multiple imputation (Rubin, 2004) to create and analyse 50 multiply imputed datasets. Incomplete variables were imputed under fully conditional specification (van Buuren et al., 2006). Model parameters were estimated with two-sided, two-sample *t*-tests applied to each imputed dataset separately. These estimates and their standard errors were combined using Rubin's rules. Calculations were performed in R (V 3.2.5, R-Foundation for statistical computing c/o Institute for Statistics and Mathematics, Vienna, Austria) using the default settings of the mice (V 2.25) package for multiple imputation (van Buuren and Groothuis-Oudshoorn, 2011) and using the ci.pd function of the Epi (V 2.0) package.

Results

Patients enrolled

A total of 99 patients were randomized, 52 to the taping group and 47 to the splinting group. Patient characteristics were similar, with no statistical difference in either the fracture type, the rate of unstable fractures or the number of displaced fractures that needed reductions (Table 1). One patient from the taping group was excluded after the first follow-up visit because he moved away. However, the parents reported a good result by telephone interview. Fourteen patients in the taping group and 11 patients in the splinting group returned for the day 42 follow-up, but missed the last consultation. They were not excluded, because all had an uneventful course until day 42 and their parents, who were reached by telephone after 6 months, reported no further worries or symptoms.

Change of treatment groups

Two patients, a 9-year-old girl and an 11-year-old boy, asked to change from taping to splinting due to pain. The girl had a stable Salter Harris (SH) II fracture of the proximal phalanx of her little finger and was changed the first day after trauma; we were not able to detect risk factors. The boy was changed on day 5 due to persistent pain. He had an oblique fracture of the proximal phalanx that may not have been immobilized sufficiently with tape only. Two boys were changed to a cast due to parental anxiety about displacement. They had no pain issues, and the treatment was finished successfully with splinting.

A change from splinting to taping was not offered within the study. However, one 12-year-old boy saw the taping of another child, and the family insisted on changing from splinting to taping against medical advice. The further follow-up was uneventful.

Primary outcome parameter

Three of the 47 patients (6.4%) in the splinting group and one of the 52 patients (1.9%) in the taping

Table 1. Patients' characteristics.

Baseline data	Taping	Splinting	*p*-value
Patients (*n*)	52	47	
Boys/girls	33/19	34/13	0.39 (Fisher)
Age (average years)	10	11	0.37 (*t*-test)
Fracture side: left/right (*n*)	35/17	33/14	0.83 (Fisher)
Digit: II/III/IV/V (*n*)	2/2/5/43	6/3/2/36	0.28 (chi-squared)
Phalanx: proximal/middle (*n*)	47/5	41/6	0.75 (Fisher)
Base/shaft/distal (*n*)	45/4/3	38/5/4	0.78 (chi-squared)
Unstable fractures	20/52 (38%)	19/47 (40%)	1.00 (Fisher)
Reduction needed (*n*)	18 (35%)	13 (28%)	0.52 (Fisher)

n: number.

Table 2. Secondary outcomes.

Measurements	Taping	Splinting	*p*-value
Comfort after 5 days (VAS)	0.9	2.0	0.01
Comfort after 21 days (VAS)	1	1.5	0.25
Analgesia intake (days)	0.3	0.5	0.37
Application time (minutes)	4.8	15.8	<0.01
Estimated cost (Euros)	38	160	
TRAM (degrees)	259	262	0.51

VAS: visual analogue scale; TRAM: total range of active motion.

group had secondary displacement of the reduced fracture.

The risk difference *p* between the taping and the splinting group for all fractures was –0·045 with a 95% confidence interval [−0.154, 0.047]. Therefore, we can conclude that taping is not inferior to splinting in our patients when we assume that an increase of up to 5% in the probability of secondary displacement is clinically irrelevant.

All secondary displacements occurred in the 31 fractures requiring reduction and all were located at the base of proximal phalanx of the little finger. The displacements were detected at the first follow-up visit on day 5 with no further displacement afterwards. All undisplaced fractures did not displace in either group.

The patient with a secondary displacement in the taping group had to be changed to splinting. Only one boy from the splinting group with a proximal shaft fracture of his left little finger needed a secondary reduction and K-wire immobilization. All the other patients were left with a minimal ulnar displacement (10°, 11°, 13°) that was not considered relevant by the patients, parents or treating team.

Secondary outcome parameters

Patient comfort as perceived by parents was recorded at the 5-day and 21-day follow-up (Table 2). It was significantly higher for the taping group after 5 days with no significant difference later. No difference was found for the duration of analgesia intake in days. All patients had normal TRAM at their final visit. The application time of a custom-made splint took three times longer than the application time of a tape. The cost of material resulted in a higher cost for splinting than for taping. No patient had severe skin lesions requiring special treatment or change of the immobilization method.

The percentage of missing values across the five variables of the secondary outcome parameters varied between 0% and 23%.

Discussion

This randomized non-inferiority trial demonstrated that the risk of secondary displacement of extra-articular paediatric finger fractures of the proximal and middle phalanges was not higher with treatment by buddy taping alone than by rigid immobilization with a forearm-based hand splint. The confidence interval was below the predefined non-inferiority of 5%. Patient comfort at an early follow-up was significantly higher in the taping group; analgesia intake and TRAM did not differ.

No secondary displacement was found in undisplaced fractures not needing reduction before immobilization. However, secondary displacement occurred in one of 18 (6%) reduced fractures in the taping group and three of 13 (23%) in the splinting group. The lower rate of secondary displacement in the taping group is encouraging, but the small numbers did not allow confirmation of the non-inferiority hypothesis of this sub-group within a 95% confidence interval.

The aim of immobilization is not only to prevent secondary displacement but to provide sufficient analgesia. Some authors have therefore recommended supplementing taping with a gutter or rigid splint in unstable, particularly oblique or spiral fractures (Nellans and Chung, 2013). We extended our indication to taping (without a further splint) to fractures that were considered unstable due to the oblique fracture type, multiple fragments or after reduction, without experiencing an increase in the rate of secondary displacement. However, one patient with an oblique fracture of the proximal phalanx of the little finger had to be changed from taping to splinting due to persistent pain at day 5, indicative of insufficient immobilization. Taping is a more dynamic immobilization and may not be sufficient to provide adequate analgesia in oblique fractures. This confirms recommendations for more rigid immobilization in oblique fractures (Nellans and Chung, 2013).

Two parents were anxious that the minimal immobilization with taping was insufficient for their children's levels of physical activity and asked for a supplementary splint. The present study provides data to reassure worried parents in the future. However, alternatives to buddy taping should be provided, and children and their parents should have the option to choose a traditional forearm-based hand splint, be it for optimal analgesia, reassurance or for preference of a child who wishes a more visible immobilization than just a tape.

Patient comfort, as perceived by parents, after 5 days was significantly higher in the taping group. This may reflect the fact that children were less

restricted with tape, which allowed water immersion and could be changed at home easily. No skin problems that changed the treatment regime were found in the study population. This contrasts with the literature, where skin macerations, pressure sores and even skin necrosis have been reported after interdigital taping (Won et al., 2014). The absence of skin problems in our study may be mainly due to the interdigital padding that was applied. Padding reduces pressure at the digital convexity of the joint, and it absorbs sweat and restricts proximal interphalangeal joint mobility to some extent. Clear instructions in how to change the taping and the provision of taping material at the first consultation may be beneficial in preventing skin problems due to moist tapes and tight tapings, particularly at an early period of progressive oedema. Compliance is an issue in all non-operative treatment modalities. Nearly two-thirds (65%) of surgeons participating in the questionnaire-based study of Won et al. observed early removal of tapes by patients against medical advice (Won et al., 2014). This non-compliance was not an issue in our patients. The paediatric age group is certainly less prone to such problems, since the parents promote adherence to protocols. Furthermore, patient instruction may be more thorough in a prospective study.

Finger fractures are very common in children, and so contribute to cost and consultation time in emergency settings (Naranje et al., 2016). Since forearm-based hand splints must be custom made for children, they are time consuming. The time difference for application and instruction was relevant; it took approximately 15 minutes for a splint and 5 minutes for a tape. This and the more expensive materials for splinting contributed to the difference in cost between 160 Euros for splinting and 38 Euros for taping. It may be very reassuring for a high-volume emergency centre with scarce resources to know that simple and readily available tape is a non-inferior treatment modality for most paediatric finger fractures.

This study has limitations. The splinting in this study was a forearm-based palmar hand splint, applied in an intrinsic plus position. This is not a splinting position used by all hand surgeons for these fractures. A shorter splint, extending from finger to the hand, is another type of splinting, which might be more comfortable. The threefold lower displacement rate in the taping group is encouraging. However, we cannot prove the superiority of either technique. All secondary displacements occurred in the subgroup of unstable fractures following reduction of displaced fractures of proximal phalanges in little fingers. This fact alerts surgeons that this type of fracture may not be treated securely with either treatment utilized in this study. We cannot make any absolute conclusions for these fractures.

Most undisplaced fractures in children's fingers are inherently stable and taping can be recommended without reservations. The higher patient comfort and the lower cost encourage us to propose taping as an alternative to splinting. Taping with interdigital padding of many displaced fractures after reduction appears to be a safe option. However, we advise that such fractures should be assessed and treated individually as we are unable to confirm that one method is superior to another.

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